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(54) Method for displaying gradation with plasma display panel

(57) A method for displaying an image with gradation and a high brightness with a plasma display panel is provided. In this method, one field is divided into eight subfields, and each subfield is divided into an addressing period and sustaining period. In the upper four bits (b_4, b_5, b_6, b_7), in which the sustaining period is long, all of the scanning electrodes are scanned sequentially. In the lower four bits (b_0, b_1, b_2, b_3), in which the sustaining period is short, the scanning electrodes are scanned alternately by interlace scanning.

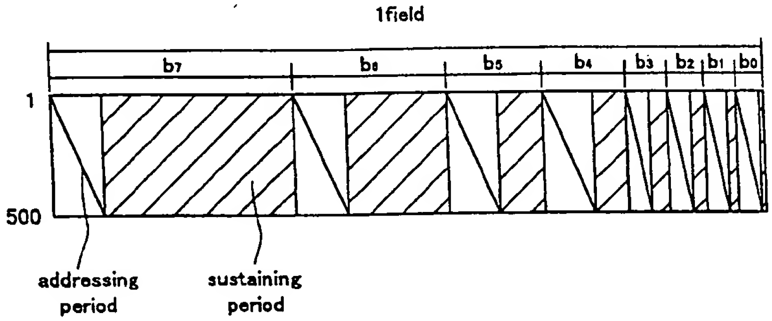

FIG. 1

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Description

This invention relates to a method for displaying gradation with a plasma display panel (hereinafter referred to as "PDP").

One such method is disclosed, for example, in the paper of the image engineering study group of The Institute of Electronics, Information and Communication Engineers, IT 72-45 (1973). In this paper, the gradation display is performed by time-dividing a field of an image into a plurality of subfields, and giving a proper weight on a luminescent period in each subfield. Thus, a linear gradation characteristic is obtained by altering a luminescent period to display a halftone in a PDP, which utilizes a discharge luminescence and in which a current or a voltage is not proportional to a luminescence.

Fig. 7 shows an example of a conventional method for displaying gradation with a PDP disclosed in JP-A-4-195188. In this method, a subfield is further divided into an addressing period and a sustaining period. In the addressing period, a binary data, i.e., on or off is written into every pixel by non-interlace scanning in which all scanning electrodes are selected sequentially. In the sustaining period following the addressing period, all pixels that have been given the on data are held emitting light for a predetermined period to display an image in a binary gradation.

Furthermore, the weight given to the sustaining period of each subfield, i.e., a ratio of the sustaining periods may be set 1, 2, 4, 8, ..., 2^{n-1} (n is a number of subfields) and all images in the subfields included in a field may be accumulated in eyes of a viewer. Thus, an image can be displayed in 64 gradation steps when n = 6, or in 256 gradation steps when n = 8.

Fig. 8 shows another example of a conventional method for displaying gradation disclosed in Japan Television Institute Memoir Vol. 38, No. 9 (1984). In this method, one field is divided into a plurality of subfields in the same way as the above-mentioned method shown in Fig. 7. However, the method shown in Fig 8 starts the sustaining period immediately after selecting one of the scanning electrodes to write data into it. This operation is different from the method shown in Fig. 7. The next scanning electrode to be selected is given data by utilizing a stop period for the light emitting pulse. The sustaining period of each subfield is given weight 2^{m-1} (m = 1, 2, ..., n) for example in the same way as the example shown in Fig. 7.

By such a method for displaying gradation, a PDP can display an image with a sufficient number of gradation levels, and it has attracted attention as realizing a so-called wall-hung TV or a flat TV in recent years.

However, the above mentioned method has the following disadvantage. The majority of the time is used for the addressing period for writing data and the sustaining period is too short to obtain a sufficient brightness of the PDP. The current mainstream is a surface discharge AC type PDP, which needs a period of approximately 2.5 microseconds for selecting a scanning electrode and writing data. In this case, if a PDP having 500 scanning electrodes is driven with 8-subfield division, the addressing period is 10 milliseconds (2.5 microseconds x 500 x 8). Therefore, only 6.7 milliseconds remain for the sustaining period in one field (16.7 milliseconds). As a result, the brightness of a PDP may be insufficient in the method of the prior art.

In order to solve the above mentioned problem of the prior art, the present invention provides a method for displaying gradation with a PDP, which comprises the steps of forming a field to include a whole scanning subfield and a partial scanning subfield, each of which includes an addressing period to scan scanning electrodes sequentially for writing image data and a sustaining period to hold the written image data, scanning all of the scanning electrodes one by one in the addressing period of the whole scanning subfield, and scanning some of the scanning electrodes in the addressing period of the partial scanning subfield.

Another displaying method of the present invention comprises steps of forming a field to include a whole scanning subfield and a quasi-whole scanning subfield, each of which includes an addressing period to scan scanning electrodes sequentially for writing image data and a sustaining period to hold the written image data, scanning all of the scanning electrodes one by one in the addressing period of the whole scanning period, and scanning all of the electrodes in a short time by selecting two neighboring scanning electrodes simultaneously in the addressing period of the quasi-whole scanning subfield.

According to each of the methods mentioned above, the addressing period can be shortened to expand the sustaining period by using an interlace scanning, and the flicker due to the interlace scanning can be suppressed.

It is preferable that the odd or even numbered scanning electrodes are scanned in the partial scanning subfield, supposing that each of the scanning electrodes has a number corresponding to the order of the arrangement. Similarly in the second method, data corresponding to the scanning electrode with either an odd number or an even number are written in the quasi-whole scanning subfield again supposing that the scanning electrodes are sequentially arranged

It is also preferable that the partial scanning subfield in which the odd numbered scanning are scanned and the partial scanning subfield in which the even numbered scanning electrodes are scanned appear alternately. Similarly it is preferable in the second method, that the quasi-whole scanning subfield in which the data corresponding to the odd numbered scanning electrode are written and the quasi-whole scanning subfield in which the data corresponding to the even numbered scanning electrode are written appear alternately.

In the accompanying drawings:

Fig. 1 is a time chart showing an example of the method for displaying gradation according to the present invention;

Fig. 2 shows an arrangement of electrodes of a PDP;

Fig. 3 is a timing chart of a subfield corresponding to an upper four bits;

Fig. 4 is a timing chart of a subfield corresponding to the odd bits of the lower four bits;

Fig. 5 is a timing chart of a subfield corresponding to the even bits of the lower four bits;

Fig. 6 is a time chart showing another example of the method for displaying gradation according to the present invention;

Fig. 7 is a time chart showing a method for displaying gradation in the prior art; and

Fig. 8 is a time chart showing another method for displaying gradation in the prior art.

The present invention is now explained in detail using examples with reference to the drawings.

Example 1

Fig. 1 shows a timing chart of an example of the method for displaying gradation according to the present invention. This example uses a PDP that has 500 scanning electrodes and realizes 256 levels of gradation. In Fig. 1, the vertical direction corresponds to the number of the scanning electrode, and the horizontal direction corresponds to time. A field is divided into eight subfields, and each of the subfields includes an addressing period and a sustaining period (i.e., a light emitting period). The sustaining period of each subfield is given a weight of 128, 64, 32, 16, 8, 4, 2 or 1 corresponding to an 8-bit digital signal (b_7, b_6, b_5, b_4, b_3, b_2, b_1 and b_0) generated by analog-digital (A/D) conversion of an image signal. In the addressing period, the scanning electrodes are scanned and data writing is performed. The scanning electrodes are selected alternately. Thus, an interlace scanning is performed in which half of the scanning electrodes are selected to shorten the addressing period.

However, if the interlace scanning is performed in every subfield, a flicker may occur in the image. The inventors studied partial interlace scanning in which the interlace scanning is performed only in subfields corresponding to lower bits that have a short sustaining period and a small contribution to the brightness. As a result of the experiment, it was found that the flicker hardly occurs when addressing the subfield corresponding to the lower four bits b_0, b_1, b_2 and b_3 whose weights in the sustaining period are 1, 2, 4 and 8 (i.e., the partial scanning subfield) by the interlace scanning, and addressing the upper four bits b_4, b_5, b_6 and b_7 whose weights in the sustaining period are 16, 32, 64 and 128 (i.e., the whole scanning subfield) by the non-interlace scanning.

The above-mentioned addressing method substantially shortens the addressing time in one field compared with the prior art. For example, if the writing time per one scanning electrode is 2.5 microseconds and the number of the scanning electrodes is 500, a total addressing period is 7.5 milliseconds (2.5 microseconds x 500 x 4 + 2.5 microseconds x 250 x 4). Therefore, 9.2 milliseconds can be assigned to the sustaining period in one field. This is 1.37 times greater than the 6.7 milliseconds in the prior art. Thus, a 40 % increase in the brightness can be obtained.

The method of driving a PDP for performing the displaying method of the present invention is explained. Fig. 2 shows an electrode arrangement of a PDP, in which M data electrodes D_1-D_M extend in the column direction, and 500 scanning electrodes SCN_1-SCN_{500} and 500 holding electrodes SUS_1-SUS_{500} extend in the row direction. The driving method for this PDP is explained referring to Figs. 3 and 4.

Fig. 3 is a timing chart of driving signals in the subfield corresponding to the upper four bits. First, in the addressing period, a positive writing pulse whose voltage is +Vw volts is applied to those data electrodes to be written data among the data electrodes D_1-D_M, and at the same time, a negative scanning pulse whose voltage is -Vs volts is applied to the first scanning electrode SCN_1, so that writing discharges occur at the cross points of data electrodes to be written and the first scanning electrode SCN_1.

Next, the positive writing pulse (+Vw volts) is applied to the data electrodes to be written data, and at the same time, the negative scanning pulse (-Vs volts) is applied to the second scanning electrode SCN_2, so that writing discharges occur at the cross points of data electrodes to be written and the second scanning electrode SCN_2.

The above explained operation is performed sequentially, the positive writing pulse (+Vw volts) is applied to the data electrodes to be written data, and at the same time, the negative scanning pulse (-Vs volts) is applied to the 500th scanning electrode SCN_{500}, so that writing discharges occur at the cross points of data electrodes to be written and the 500th scanning electrode SCN_{500}. Thus, image data is written into the PDP.

Next, in the sustaining period, a negative sustaining pulse whose voltage is -Vs volts is applied to all of the holding electrodes SUS_1-SUS_{500} so as to start sustaining discharges at the points where the writing discharges have occurred. Then, a negative sustaining pulse whose voltage is -Vs volts is applied to all of the scanning electrodes SCN_1-SCN_{500}.

The writing operation and the sustaining operation are performed alternately so that the sustaining discharge succeeds the writing discharge at the points to be written image data. Thus, the image is displayed.

Fig. 4 is a timing chart of driving signals in the subfield corresponding to the odd bits (b_1 and b_3) of the lower four bits. First, in the addressing period, a positive

writing pulse whose voltage is +Vw volts is applied to those data electrodes to be written data among data electrodes D_1-D_M, and at the same time, a negative scanning pulse whose voltage is -Vs volts is applied to the first scanning electrode SCN_1, so that writing discharges occur at the cross points of data electrodes to be written and the first scanning electrode SCN_1.

Next, the positive writing pulse (+Vw volts) is applied to the data electrodes to be written data, and at the same time, the negative scanning pulse (-Vs volts) is applied to the third scanning electrode SCN_3, so that writing discharges occur at the cross points of data electrodes to be written and the third scanning electrode SCN_3.

As mentioned above, the scanning electrodes are selected alternately to write data in the PDP until the 499th scanning electrode receives the negative scanning pulse (-Vs volts) and the positive writing pulse (+Vw volts) is applied to data electrodes to be written data so that writing discharges occur at the cross points of data electrodes to be written and the 499th scanning electrode SCN_{499}.

According to the above-mentioned operation, image data are written in the PDP. Then the operation in the sustaining period is performed in the same way as explained referring to Fig. 3.

Fig. 5 is a timing chart of driving signals in the subfield corresponding to the even bits (b_0 and b_2) of the lower four bits. First, in the addressing period, a positive writing pulse whose voltage is +Vw volts is applied to those data electrodes to be written data among data electrodes D_1-D_M, and at the same time, a negative scanning pulse whose voltage is -Vs volts is applied to the second scanning electrode SCN_2, so that writing discharges occur at the cross points of data electrodes to be written and the second scanning electrode SCN_2.

Next, the positive writing pulse (+Vw volts) is applied to the data electrodes to be written data, and at the same time, the negative scanning pulse (-Vs volts) is applied to the fourth scanning electrode SCN_4, so that writing discharges occur at the cross points of data electrodes to be written and the fourth scanning electrode SCN_4.

As mentioned above, the scanning electrodes are selected alternately to write data in the PDP until the 500th scanning electrode receives the negative scanning pulse (-Vs volts) and the positive writing pulse (+Vw volts) is applied to data electrodes to be written data so that writing discharges occur at the cross points of data electrodes to be written and the 500th scanning electrode SCN_{500}.

According to the above-mentioned operation, image data are written in the PDP. Then the operation in the sustaining period is performed in the same way as explained referring to Fig. 3.

Example 2

Another example of the present invention is explained referring to Fig. 6. In this example, one field is divided into eight subfields, in each of which data is written for one scanning electrode, and at once, the sustaining period starts. The sustaining period of each subfield is given a weight of 128, 64, 32, 16, 8, 4, 2 or 1 corresponding to an 8-bit digital signal (b_7, b_6, b_5, b_4, b_3, b_2, b_1 and b_0) generated by A/D conversion of an image signal. Then, the image data are written for a scanning electrode sequentially utilizing the sustaining period that is a pulse resting period.

In the subfield corresponding to the upper four bits (b_4, b_5, b_6 and b_7), data are written for every scanning electrode. However, data are written for every other scanning electrode in the subfield corresponding to the lower four bits (b_0, b_1, b_2 and b_3). In other words, an interlace scanning is performed in the subfield corresponding to the lower four bits. Thus, the period of the subfield corresponding to the upper four bits becomes 1.5 times that of the prior art, resulting in a 40 % increase in the brightness.

In the subfield that performs an interlace scanning, the subfield corresponding to the odd bits b_1 and b_3 may select the odd number of scanning electrodes SCN_1, SCN_3, ..., SCN_{499}, while the subfield corresponding to the even bits b_0 and b_2 may select the even number of scanning electrodes SCN_2, SCN_4, ..., SCN_{500}. Thus, every scanning electrode is selected to address in one field.

As an alternative method of interlace scanning, two neighboring scanning electrodes may be selected simultaneously in the subfield that does not perform the non-interlace scanning (i.e., a quasi-whole scanning). Also in this case, the addressing period can be shortened by shifting the two neighboring scanning electrodes by one scanning line for writing data in the same way as the interlace scanning.

The number of the subfield that performs the interlace scanning among the lower bits is not limited to the example explained above, but may be an optimum number depending on the number of the scanning electrodes, the method of giving weight to the subfield, and the characteristics of the PDP.

In a specific subfield, when the interlace scanning or the quasi-whole scanning is performed, the sustaining period of each subfield may be given a weight so as to adjust to the interlace scanning or the quasi-whole scanning beforehand. Thus, a linearity of the brightness in the displayed image can be stable.

The linearity of the brightness can be improved also by compensating an alteration of the brightness due to the interlace scanning or the quasi-whole scanning in a stage processing an image signal beforehand. In addition, by combining this method with the adjustment of the weight given to the sustaining period of the subfield mentioned above, the linearity of the brightness can be

improved.

As explained above, the present invention can provide a method for displaying an image in a PDP with an increased brightness by shortening the addressing period, without losing its advantage of little image flicker.

Claims

1. A method for displaying gradation with a plasma display panel, the method comprising the steps of:

   forming a field to include a whole scanning subfield and a partial scanning subfield, each of which includes an addressing period to scan scanning electrodes sequentially for writing image data and a sustaining period to hold the written image data;
   scanning all of the scanning electrodes one by one in the addressing period of the whole scanning subfield; and
   scanning some of the scanning electrodes in the addressing period of the partial scanning subfield.

2. The method according to claim 1, wherein the scanning electrodes with either an odd number or an even number are scanned in the partial scanning subfield, supposing that the scanning electrodes are sequentially arranged.

3. The method according to claim 2, wherein the partial scanning subfield in which the scanning electrodes with an odd number are scanned and the partial scanning subfield in which the scanning electrodes with an even number are scanned appear alternately.

4. The method according to claim 1, wherein the whole scanning subfield is a subfield corresponding to the highest brightness signal.

5. A method for displaying gradation with a plasma display panel, the method comprising the steps of:

   forming a field to include a whole scanning subfield and a quasi-whole scanning subfield, each of which includes an addressing period to scan scanning electrodes sequentially for writing image data and a sustaining period to hold the written image data;
   scanning all of the scanning electrodes one by one in the addressing period of the whole scanning period; and
   scanning all of the electrodes by selecting two neighboring scanning electrodes simultaneously in the addressing period of the quasi-whole scanning subfield.

6. The method according to claim 5, wherein data corresponding to the scanning electrode with either an odd number or an even number are written in the quasi-whole scanning subfield supposing that the scanning electrodes are sequentially arranged.

7. The method according to claim 6, wherein the quasi-whole scanning subfield in which the data corresponding to the scanning electrode with an odd number are written and the quasi-whole scanning subfield in which the data corresponding to the scanning electrode with an even number are written appear alternately.

8. The method according to claim 5, wherein the whole scanning subfield is a subfield corresponding to the highest brightness signal.

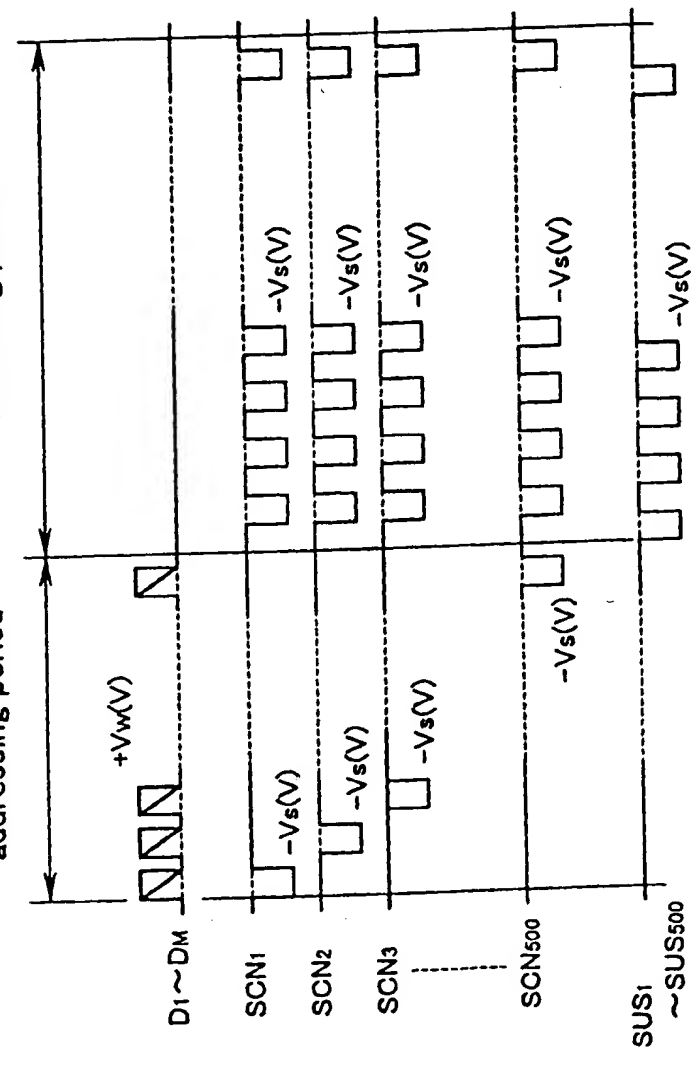
addressing period
sustaining period
+Vw(V)
-Vs(V)
D1～DM
SCN1
SCN2
SCN3
SCN500
SUS1
～SUS500

FIG. 3

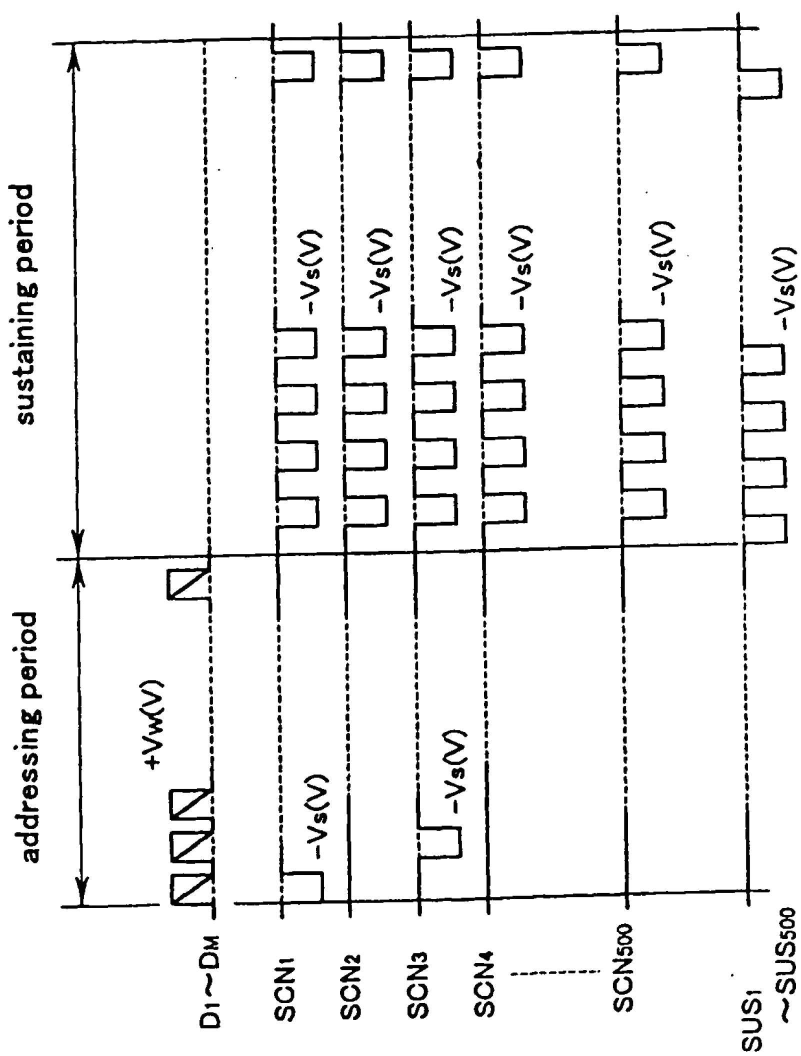
addressing period
sustaining period
+Vw(V)
-Vs(V)
D1~DM
SCN1
SCN2
SCN3
SCN4
SCN500
SUS1 ~SUS500

FIG. 4

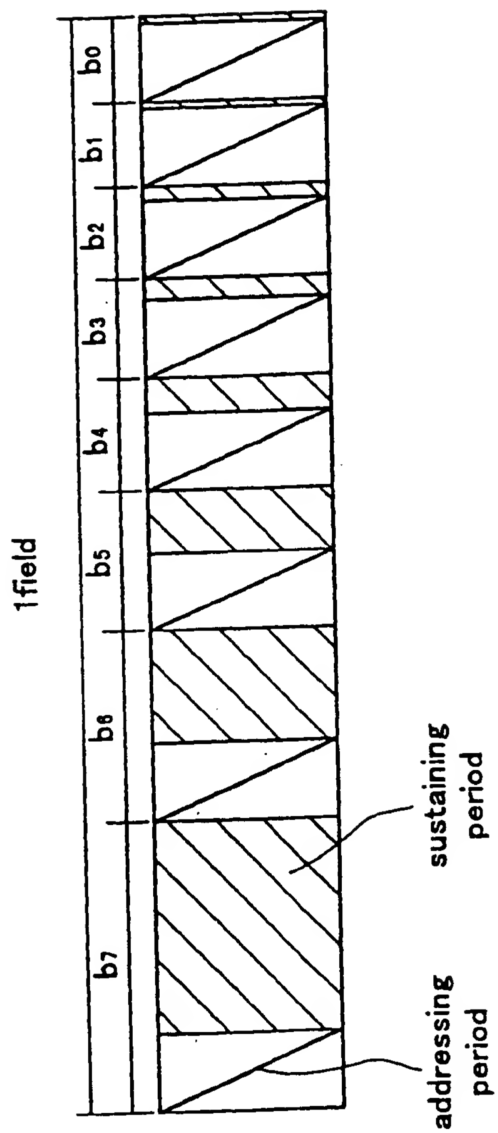

FIG. 7
(PRIOR ART)

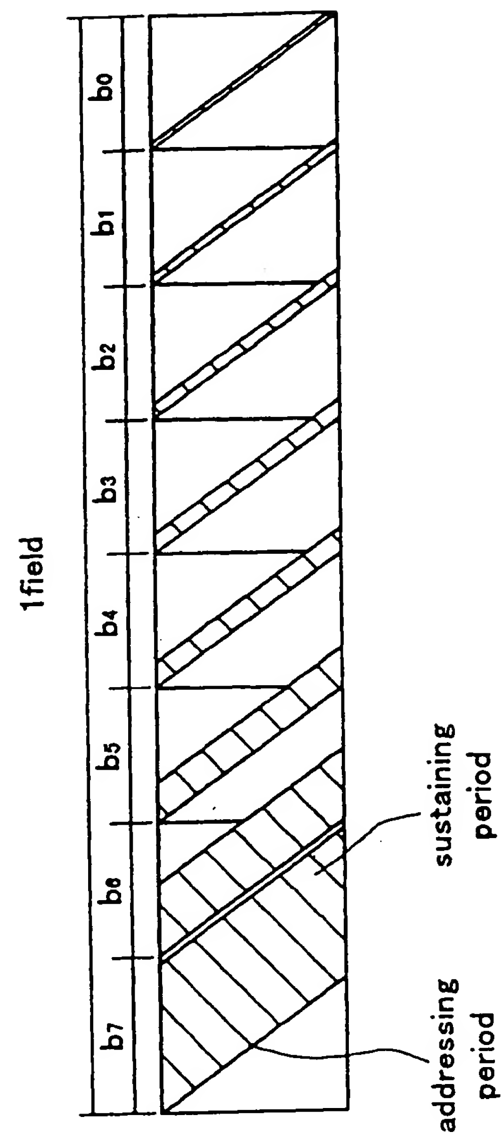

FIG. 8
(PRIOR ART)

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EUROPEAN SEARCH REPORT

Application Number
EP 98 11 2007

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X,D A	EP 0 488 891 A (FUJITSU LTD) 3 June 1992 * Whole document * ---	1 2-8	G09G3/28
X A	EP 0 755 043 A (FUJITSU GENERAL LTD) 22 January 1997 * Whole document * ---	1 2-8	
X A	EP 0 488 326 A (NIPPON ELECTRIC CO) 3 June 1992 * Whole document * -----	1 2-8	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
G09G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	28 October 1998	Aratari, R

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